Typically, only 10% of the microwave systems in the United States employ space diversity[15]. It may thus be assumed that 9 out of 10 microwave receivers in the Houston area do not currently employ space diversity. In addition, it may be conservatively assumed that the average fade margin of the second antenna is equal to the original average fade margin of 46 dB[16]. Therefore, Fs = 46 dB will result in the microwave receiver reliability being improved by 23 dB (200-fold) with the addition of this diversity technique. This corresponds to a 22.5 dB (180-fold) improvement, on average, for the entire Houston microwave community. This additional improvement in reliability provides for greater flexibility in spectrum utilization. A co-primary user, such as a PCN provider, could emit a significant amount of additional energy in deploying its system. For example, a PCN system could transmit 13 dB more power if space diversity is employed without affecting the pre-diversity fade margin of the microwave receivers. In essence, the additional 10 dB of energy will reduce the system and secondary fade margins to 36 dB. However, the resulting 14 dB improvement in the 33 dB resulting fade margin will more than compensate for the additional 13 dB of interfering power. The result is that, for a fixed cell distribution, PCN could accommodate 20 times more users if the microwave users employed diversity. Or, for a fixed user distribution, the cell radii could be increased by a factor of approximately 4 times, effectively reducing the number of cells by a factor of 20. For example, if 5000 cells were required to cover the Houston area and without exceeding TSB-10E, this number could be theoretically reduced to 250 cells if space diversity was employed in the microwave receivers. Of course, cell capacity limitations will act as a lower bound on the number of cells required to serve any assumed traffic load.

1.2.2.2 *Angle Diversity*

Angle diversity is a technique which, although not widely employed in today's microwave systems, can also be used to greatly improve system reliability. Angle diversity involves utilizing two antennas (with one parabolic dish) which are displaced off of the boresight of the dish by less than 1 degree. The objective of this technique is to capture the strongest multipath signal arriving at the dish, select that signal to demodulate, and thereby improve system performance.

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15 "Comments of the Utilities Telecommunications Council in the Matter of Amendment of the Commission's Rules to Establish Personal Communications Services",October 1, 1990.

16 PCN America has learned from the Houston Area Microwave User Group that many of their systems having space diversity achieve essentially the same fade margin on both antennas.

A number of studies have been performed on this technique. Experiments by the NTIA[17] and SIGNATRON, Inc.[18] have shown performance *improvement due to angle diversity to be comparable to that of space diversity*. Because angle diversity does not require the amount of "real estate" that space diversity does (two antennas with 30 - 50 feet of separation on an antenna tower), it can be utilized in almost any situation. Specifically, angle diversity can be employed in downtown urban areas, where building top antenna mounts may make space diversity implementation quite difficult.

1.2.2.3 *Frequency Diversity*

Frequency diversity describes the technique of using two offset frequency paths over the same microwave link to combat the effects of frequency-selective fading. The improvement due to frequency diversity is related to the frequency separation, fade margin and transmit frequency, and has been found to be somewhat less effective than either space or angle diversity.

Because frequency diversity requires essentially twice as much spectrum, it should not be considered a viable alternative for spectrum sharing. Space diversity and angle diversity are much more attractive because they do not require increased spectrum.

1.2.3 Modern Digital Radios are Better Suited to Co-Existence

In the 1.85 to 1.99 GHz band, 90% of the current microwave operators use FM-FDM analog radios. On these analog radios, about half of the capacity is devoted to voice and the other half to data transmission[19]. The voice transmissions on analog radios are particularly susceptible to RF interference. For good quality voice reception (app. 70 dB S/N baseband), a typical analog radio requires a received signal level on the order of 40 dB above the FM threshold level of the receiver[20]. As noise increases in the system, analog voice quality will linearly decrease until threshold is reached. This linear variation causes data transmission on analog channels to reach the

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[17] Hubbard, R.W. "Angle Diversity Reception for LOS Digital Microwave Radio", *Proceedings of IEEE MILCOM-85*, Paper 19.6, 1985.

[18] Malaga, A. and Parl, S.A. "Experimental Comparison of Angle and Space Diversity for Line-of-Sight Microwave Links", *Proceedings of IEEE MILCOM-85*, Paper 19.5, 1985.

[19] "Comments of the Utilities Telecommunications Council in the Matter of Amendment of the Commission's Rules to Establish Personal Communications Services",October 1, 1990.

[20] Roelofs, S. "Microwave System Design; Noise Performance", Motorola Publication R39-00-16.

threshold of a typical modem (BER = 10^{-6}) before the receiver threshold is reached. The data signal can be muted up to 20 dB above the receiver threshold[21].

Digital radios do not require a large fade margin for good voice or data transmission. The BER performance of digital radios is flat with respect to additive noise up to about 10 dB above threshold. This enables the digital system to operate at a considerably lower level than the analog system and still maintain similar performance. In addition, digital radio is considerably more spectrally efficient than analog[22], and channel performance is consistent for all channel assignments[23]. It is important to note that even at threshold on a digital receiver (BER = 10^{-6}), performance may still be acceptable for voice communications, as "one might hear an infrequent 'click'"[24] with the voice otherwise being perfectly understandable down to a BER of 10^{-3}.

Figure 3 illustrates a comparison of "quieting curves" for typical digital and analog radios. Note that a reduction in signal level has minimal effect up to about 10 dB above threshold on a digital radio, while it has a large effect on analog radio performance.

In addition to these inherent performance advantages, digital radios can be equipped with several enhancements to further improve performance. These include forward error correction (*FEC*) and Adaptive Power Control (*APC*).

1.2.3.1 *Forward Error Correction*

The use of simple FEC techniques in digital microwave radio can improve system performance by 2 to 4 dB over systems without FEC. This improvement results directly in a 2 to 4 dB increased resistance to outside interference, such as may be generated by a PCS, and is therefore of great benefit in the co-existence effort. Although not currently implemented on many digital radios, implementation appears to be desirable and feasible for new production microwave radios.

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[21] Erickson, P. "T1 Data Modem on an Analog Microwave System", Motorola Publication R39-00-11, 1987.

[22] On analog radios, the channel performance degrades with frequency. The top baseband channel can be up to 10 times more susceptible to interference than the lowest baseband channel.

[23] Stedman, R. "Multi-Hop Comparison of Digital and Analog Microwave Systems", Motorola Publication R39-16-118, 1991.

[24] "Telecommunications Systems Bulletin 10-E, Rev. D", Telecommunications Industry Association, August 3, 1992, p.24.

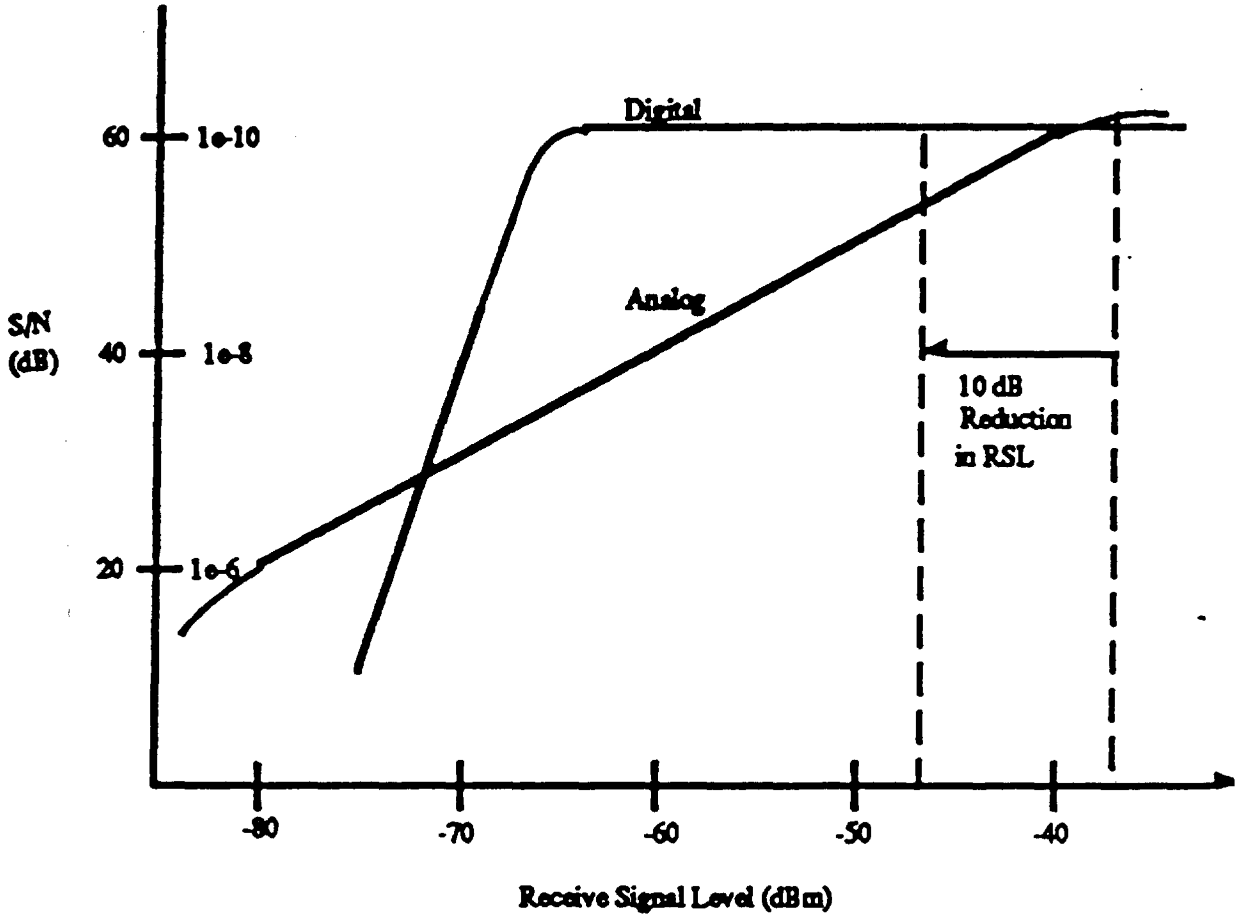

Figure 3 - Comparison of Analog and Digital Radio Performance

1.2.3.2 *Adaptive Power Control*

"Adaptive Power Control (APC) is a technique which allows a digital microwave radio transmitter to operate several dB below its rated maximum power more than 99% of the time and yet automatically provide maximum power when required by a serious fade"[25]. Typically, an APC system will monitor the receive level and pre-FEC BER of the receiver, and increase power when two events occur simultaneously:

1) Received power is within a certain tolerance of threshold (e.g. 15 dB)

2) BER = 10^{-10}

The maximum power needed for an APC digital microwave radio would be equivalent to the nominal power required by a non-APC radio. Typically, an APC radio can employ a transmit power 6 dB lower on average than a non-APC radio. This reduces the power required by the radios, increases the equipment reliability, maintains path reliability and effectively reduces the microwave interfering power into a PCS system by 6 dB.

1.3 **Instantaneous Interferers**

It is possible that a fully mobile PCS unit may enter a location where propagation between the handset and a microwave receiver will be on the order of *free space loss*. Line of site roof tops, high viaducts and building balconies (in direct line of site to a receiver) are examples of locations where such an occurrence could take place. In addition, through certain existing building structures, the loss could be less than mobile propagation formulae predict.

It is difficult to assign a probability to such occurrences. A conservative assumption would be that 5% of all mobile units are in a location to potentially propagate at free-space loss to a microwave receiver. It may be further assumed that there is 0.03 Erlang traffic loading per user[26], and that these units are transmitting at a duty cycle of 1/2. In addition, it may be assumed that the microwave path is experiencing continuous Raleigh-distributed fading[27].

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[25] Louis, E. V. "Automatic Power Control in Digital Microwave Radio Systems", Motorola Publication R39-16-119, 1991.

[26] This is equivalent to the composite per line time loading of the PSTN in the United States for the year ending 1990. See Appendix I-1 for a detailed derivation of this number.

[27] Raleigh fading is a true worst-case assumption for multipath fading that will occur along a microwave link.

In PCNA's study of the Houston area microwave receivers, it was found that the worst-case free-space interferer exceeded the TSB-10E limitations by 18 dB. Assuming a 35 dB fade margin on the victim non-diversity link, the probability of the PCS "rogue" transmitter degrading a microwave receiver to threshold is:

$$\begin{aligned} P_{thresh} &= P_{free\text{-}space} * P_{transmitting} * P_{17\ dB\ Fade} \\ &= 0.05 * 0.03/2 * 0.02 \\ &= 0.000015 \end{aligned}$$

Without PCS "rogues", the resulting probability would be:

$$\begin{aligned} P_{thresh} &= P_{35\ dB\ Fade} \\ &= 0.00032 \end{aligned}$$

Thus, the probability of a "rogue" PCS handset degrading a microwave receiver to threshold is considerably less than the probability of the interference-free receiver degrading to threshold. This is equivalent to reducing the fade margin of the receiver by

$$10\log[(0.00032 + 0.000015)/0.00032] = 0.19\ \text{dB}$$

thereby increasing the annual outage time by only **2.7 sec/yr.**

2 Other Related Issues

2.1 Aggregation of PCS Power

The concern has been raised with mobile services that due to the inexact whereabouts of any particular mobile unit, the aggregate effect of all mobile transmitters on each microwave receiver must be considered. This is the approach which PCN America has employed to date, summing the aggregate interference effect of all PCN handsets and base stations out to the radio horizon, on each and every microwave receiver in Harris County. However, TSB-10E explicitly states on page 7 "No matter how complex a total interference analysis may be, it always treats some number of individual potential exposures, each of which must be resolved *independently*. Each exposure involves **one transmitter** and **one receiver**, and the question to be answered is 'Does this transmitter interfere with this receiver?'". Obviously, TSB-10E was designed for a "one-on-one" approach, and does not consider the aggregate system interference effect in its approach.

In Appendix F of the PCS NPRM, the FCC recommends that the interference from all sources (mobiles *and* base stations) be summed at the microwave receiver, assuming straight power addition. This recommendation contradicts the intent of TSB-10E (as shown above) and imposes much stricter interference criteria on the PCS operator. If an aggregate interference analysis is required of PCS transmitters, it should also be required of the microwave transmitters. Therefore, unless TSB-10E is applied on a base station-by-base station, or user-by-user basis, it should not be applicable to PCN interference considerations.

2.2 PCS Power and Antenna Height Limitations

Because of spectrum sharing, PCS power limitations must be considerably lower than cellular limits. Limits suggested in paragraph 115 of 10 Watts EIRP and 300 feet antenna height for the base station are reasonable for spectrum sharing. This would allow for adequate PCS cell coverage areas (up to 4 miles in rural, or open areas[28]) while still maintaining low enough power for microwave coexistence. Larger cells would not be necessary due to the large projected demand for PCS and cell capacity limitations. The greater antenna heights and power as suggested in paragraph 116 would make spectrum sharing nearly impossible, and should not be necessary to provide PCS in a given area.

The mobile power limitation suggest in paragraph 115 (2 Watts EIRP) is too high also. In order to build a lightweight, cost-effective handset at 2 GHz, it has been widely accepted in the industry that output power must be kept at or below 600 mW. A lower output power would also reduce the potential aggregate power into the microwave receivers and thereby ease spectrum sharing.

2.3 Coordination Distance

In paragraph 117 of the PCS NPRM, the commission indicates that "we would require parties desiring to implement PCS operations to demonstrate protection to all co-channel and adjacent channel microwave receivers within 201 km (125 mi) of any PCS base station." PCN America disagrees with this requirement for two reasons:

1.) This requirement results in coordination over distances which are beyond line-of-sight, and

2.) It does not take into account the various antenna heights which may be used for the base stations.

The maximum radio path distance is a function of the antenna heights of the PCS interferer and the microwave receiver, as referenced to an average ground level. Assuming a maximum PCS Base Station antenna height of 295 feet and a maximum

28 "PCN America Quarterly Report to the FCC", PCN America, Inc., February 18, 1992.

microwave antenna height of 3280 feet, as stated in paragraph 117, the maximum radio path distance (in miles) can be calculated from the following equation[29]:

$$L_{max} = \sqrt{(2h_t)} + \sqrt{(2h_r)} = \sqrt{(2*295)} + \sqrt{(2*3280)} = \textit{105 miles.}$$

This distance is considerably less than the proposed 125 miles, and would reduce the coordination requirements, in terms of area, from 49,000 square miles per base station to 34,600 square miles per base station, or a reduction of almost **30%**. PCN America sees no reason to extend the coordination distance beyond the maximum radio path distance and urges the commission to limit the coordination distance to line-of-sight conditions.

PCN America also urges the commission to specify coordination distances on a case-by-case basis, taking into account the proposed base station antenna height and actual microwave antenna height to determine the coordination zone for each base station. This will result in a considerable savings in coordination time and effort for the PCS provider, while still affording the microwave receivers adequate protection.

2.4 Propagation Equations/Loss Factors

2.4.1 Outdoor Propagation Modelling

PCN America believes that statistical propagation modelling is appropriate not only for mobile propagation modelling (as stated in Appendix F of the PCS NPRM), but also for base station propagation modelling. Statistical models, such as the Hata model or the model developed by PCN America[30], take into account the effect of obstructions in an area and relative antenna heights to determine signal loss. In dense urban areas, propagation conditions will differ significantly from free-space conditions, while in rural areas, they will be close to free-space conditions.

PCN America firmly believes that imposing free-space propagation constraints for base station/microwave coordination will provide microwave users with more protection than is required, and therefore result in an inefficient utilization of the shared spectrum. Use of a modelling technique which takes into account actual obstructions in the interfering path would be most accurate. Such a model is the Terrain integrated Rough Earth Model, or TIREM. It is a propagation model which uses terrain profiles to compute basic transmission loss in the frequency range of 40

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[29] *Naval Shore Electronics Criteria, Line-of-Sight Microwave and Tropospheric Scatter Communication Systems*, NAVELEX 0101, 112, U.S. Department of the Navy, Washington, D.C., May 1972.

[30] "PCN America Quarterly Report to the FCC", PCN America, Inc., February 18, 1992.

MHz to 20 GHz and considers both ground wave and tropospheric-scatter modes of propagation. The effects of atmospheric absorption are also considered.

Terrain profiles to be analyzed are created from a series of discrete points along a path represented by a distance and elevation above sea level. Usually, this information is obtained from a digitized terrain database, but other types of terrain data can be used.

For the calculation process, the model examines the terrain profile to determine the radio horizon distance, effective antenna heights and path angular distances. Refractive effects of the earth's atmosphere are accounted for by using an effective earth's radius. With these parameters identified, an initial mode of propagation is selected. These are line-of-sight and weighted combination.

The model then performs the actual calculations. With 12 subroutines from which to choose, TIREM is capable of analyzing the effects of radio transmissions over any terrain feature. It is one of the most detailed propagation models available and is highly accurate in determining radio coverage.

Currently, PCN America is running propagation tests abroad to more exactly characterize PCS propagation. The data will be referenced to GPS-derived coordinates, and path loss will be calculated. The results will be compared to theoretical predictions based on the TIREM model, and statistical corrections to the model will be made based on the results. A similar technique has also recently been used in this country[31]. Such a model, based on actual obstructions, both man-made and natural, is more accurate in determining path loss than the statistical models, and should be used where possible. However, in situations where such data is unavailable, a statistical approach (Hata or otherwise) will be vastly more accurate than a free space model[32].

2.4.2 **Indoor Propagation Modelling**

PCN America agrees with the commission's statement in Appendix F of the NPRM that "...the equivalent portable EIRP should be weighted according to the estimated portion of portables expected to be operated inside buildings at any given time..." Those portables which may be operating on balconies or rooftops, however, must be

[31] Lemon, David G. et al, "Integration of Empirical RF Data with Propagation Prediction Models", Proceedings of the 41st IEEE Vehicular Technology Conference, 1991, pp. 307-313.

[32] In PCN America's May Quarterly Report, validation of its statistical model was performed, showing that free-space conditions, if they exist at all on the Earth's surface, are truly a rare exception to the rule.

considered separately. As shown in section 1.3 ("Instantaneous Interferers"), a single portable operating from a balcony/rooftop under free-space conditions will have a negligible effect on the microwave system reliability. We believe the odds of multiple units operating simultaneously off of balconies or rooftops are slim, and should not be considered in an interference analysis.

Once an estimate is made as to the percentage of users located in-building in a cell (PCN America believes that typically 80% of the users in an urban area will be indoor users), the loss from each floor to the outside of the building should be calculated. To do this, the discrimination angle (θ) between the victim receiver and the portable-occupied floor must be calculated. The resultant building loss may then be determined using the following formula, as derived from experimental data[33]:

$$\theta < 40°: \quad L_{bldg} = 22.67 + \theta/4 \quad (\sigma = 4.6)$$
$$\theta \geq 40°: \quad L_{bldg} = 35.19 \quad (\sigma = 1.0)$$

The average building loss is a minimum of about 23 dB (θ=0), and increases to a maximum of 35 dB. Once this loss is taken into account for each floor, the appropriate outdoor propagation model should be used to calculate path loss, based on a transmitter height equivalent to the floor height within the building.

3 Recommendations

Based on the foregoing, PCN America makes the following recommendations in the interest of spectrum sharing and efficiency. The recommendations follow closely those made to TR14.11 by the Telocator T&E Subcommittee in their letter dated April 27:

1) **0.0001 Nominal Outage Probability (NOP)** - Each link in a microwave system should not be allowed to be degraded by a PCS interferer to below a 0.0001 Nominal Outage Probability (NOP), which is equivalent to a 0.9999 non-diversity system availability. Specific cases are described below:

Analog Links:

Criteria:

The PCS system shall not reduce the normal outage probability (NOP_L) of an analog microwave link to below:

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[33] "PCN America Quarterly Report to the FCC", PCN America, Inc., February 18, 1992.

$NOP_L = NOP_S \times d / D$

where

NOP_S = System Outage Probability
= 0.0001 for diversity* systems or
= 0.001 for non-diversity systems
d = Path Length
D = System Length

Calculation:

1.) $F_{allowed} = 10\log[(a \times b \times f \times D^3 \times 2.5 \times 10^{-6})/(I \times NOP_L)]$

where

a = terrain factor
b = temperate humidity factor
f = frequency in GHz
D = Path Length in miles
F = Thermal Fade Margin in dB
$F_{allowed}$ = Allowed Fade Margin, in dB, based on the criteria above.
s = Antenna Spacing in feet
I = Space Diversity Improvement Factor
= $7 \times 10^{-5} \times f/D \times s^2 \times 10^{F/10}$
= 1 for non-diversity

2.) $PCN_{margin} = F_{allowed} - F_{actual}$

where

F_{actual} = Actual Fade Margin of the microwave link, in dB.
PCN_{margin} = The amount of energy above the TSB-10E limitation that the PCN signal is allowed, in dB.

3.) $PCN_{allowed} = N_{thermal} + 10\log(B_{PCN}/B_{\mu W}) + N_{1dB} + PCN_{margin}$
$= 10\log(kTB_{\mu W}) + NF + C_{dBm/dBw} + 10\log(BW_{PCN}/BW_{\mu W}) - 10\log(0.25) + PCN_{margin}$

where

$PCN_{allowed}$ = The allowable PCN signal level at the microwave receiver, in dBm.
$N_{thermal}$ = Thermal Noise of the microwave receiver
B_{PCN} = The half-power bandwidth, in MHz, of the PCN CDMA system
$B_{\mu W}$ = The half-power bandwidth, in MHz, of a typical 10 Mhz microwave receiver
N_{1dB} = The TSB-10E incremental noise allowance
k = Boltzman's Constant
T = Temperature, in degrees Kelvin
NF = The noise figure of the microwave receiver
$C_{dBm/dBw}$ = The conversion factor from dBw to dBm

Digital Links:

Criteria:

The PCS system shall not reduce the normal outage probability (NOP_L) of an digital microwave link to below:

NOP_L = 0.0001 for diversity* systems or
= 0.001 for non-diversity systems

Calculation:

1.) $F_{allowed} = 10\log[(a \times b \times f \times D^3 \times 2.5 \times 10^{-6})/(I \times NOP_L)]$

where

a = terrain factor
b = temperate humidity factor
f = frequency in GHz
D = Path Length in miles
F_c = Composite Fade Margin in dB
= $-10\log(10^{-F/10} + 10^{-Fd/10})$
F = Thermal Fade Margin in dB
F_d = Dispersive Fade Margin in dB (from Manufacturer)
$F_{allowed}$ = Allowed Fade Margin,in dB,based on the criteria above.
s = Antenna Spacing in feet
I = Space Diversity Improvement Factor
= $7 \times 10^{-5} \times f/D \times s^2 \times 10^{Fc/10}$
= 1 for non-diversity

2.) $PCN_{margin} = F_{allowed} - F_{actual}$

where

F_{actual} = Actual Fade Margin of the microwave link, in dB.
PCN_{margin} = The amount of energy above the TSB-10E limitation that the PCN signal is allowed, in dB.

3.) $PCN_{allowed} = R_{th} - T/I + PCN_{margin}$

where

$PCN_{allowed}$ = The allowable PCN signal level at the microwave receiver, in dBm.
R_{th} = Receiver Threshold based on 10^{-6} BER
T/I = The Threshold to Interference ratio, in dB, of the microwave receiver based on modulation method (typically around 30 dB).

Adjustments:

1.) For microwave links at or below the NOP_L specified above, the PCS system interference shall not exceed the following limitation:

Analog:

$$PCN_{allowed} = N_{thermal} + 10\log(B_{PCN}/B_{\mu W}) + N_{1dB}$$
$$= 10\log(kTB_{\mu W}) + NF + C_{dBm/dBw} + 10\log(BW_{PCN}/BW_{\mu W}) - 10\log(0.25)$$

Digital:

$$PCN_{allowed} = R_{th} - T/I + PCN_{margin}$$

2.) **Service Criticality Factor (SCF)** - The NOP can be adjusted up or down by the SCF. The SCF cannot exceed 7 dB, and must average 0 dB across the country.

3.) **TSB-10E Limitations Shall Apply to Links at/below 0.9999 Availability** - For links less than or equal to 0.9999 non-diversity availability, PCS interferers shall not be permitted to exceed TSB-10E (e.g. 1 dB threshold degradation).

4.) **50% Fade Margin Limitation for "Instantaneous" Interferers** - For PCS "instantaneous" interferers, such as the "rogue" handset which transmits temporarily under free-space propagation conditions (*e.g. on a roof-top or balcony*), shall be allowed to temporarily degrade a victim microwave receiver down to half of its existing fade margin.

5.) **Use Diversity to Improve Availability** - For certain microwave systems requiring greater availability (e.g. for long-haul systems), diversity techniques, such as space or antenna diversity, may be used to achieve the desired objectives without an increase in fade margin requirements. In addition, diversity techniques could be employed to allow for increased PCS transmissions (*above constraint #1*), at the expense of the PCS provider.

6.) **Potential Upgrading of Urban Systems to Digital Radio** - Urban systems, which are most susceptible to PCS interference, could be upgraded to digital radio, employing APC and FEC to improve robustness to PCS transmissions, in situations where PCS interference exceeds the above requirements at the expense of the PCS provider.

7.) **Move Systems to Higher Frequency Band as Last Resort** - If recommendations 1 through 5 cannot be met in the current frequency band, individual links may be moved to a higher frequency band at the expense of the PCS provider. For example, relatively short paths in the 2 GHz band (under 10 miles) may be moved to OFS bands above 10 GHz[34], and longer paths may be moved to the 6 GHz band.

8.) **Aggregation of PCS Power** - PCS power levels should not be aggregated unless the TSB-10E standard is modified to require aggregation of microwave transmitters.

9.) **Coordination Distance** - Interference coordination should not be required beyond the radio horizon. The distance should be calculated on a case-by-case basis according to the antenna height of the PCS transmitter and microwave receiver above average ground level.

10.) **Outdoor Propagation Equations** - Ideally, path loss models which take into account the actual terrain and obstructions (such as TIREM) should be used, but statistical models (such as Hata) may also be appropriate in some situations. In no instance should a free-space loss model be used.

11.) **Loss Factors** - Building loss factors based on the relative elevation of each floor with respect to the microwave receiver antenna height should be utilized for multistory buildings.

PCN America believes these recommendations to be crucial to insure successful and efficient spectrum sharing between PCS providers and OFS microwave users.

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[34] "Notice of Proposed Rulemaking in the Matter of Redevelopment of Spectrum to Encourage Innovation in the use of New Telecommunications Technologies", Federal Communications Commission, February 7, 1992.

Appendix I-1

From "Preliminary Statistics of Communication Common Carriers" for the year ending December, 1990:

Category	Calls (Lines)	Call-Minutes/Yr
Local Calls	400,337,030,000	N.A.
Intralata Toll Calls	20,085,374,000	N.A.
Interlata/Interstate Calls*	33,747,738,000	278,135,318,000
Interlata/Intrastate Calls*	11,130,006,000	90,004,273,000
Business Single-Lines	15,258,909	N/A
Business Multi-Lines	20,569,866	N/A
Public Lines	1,677,195	N/A
Residential Lines	88,416,430	N/A
Mobile Lines	23,734	N/A

**Includes both originating and terminating access minutes of use*

Calculations:

Average Minutes per Call (Interlata) = [(278,135,318,000 + 90,004,273,000) ÷ (33,747,738,000 + 11,130,006,000)] ÷ 2
= 4.1 min/call

Assuming 4.1 min/call Intralata Toll and Local:

Total Interlata Call-Minutes	= (278,135,318,000 + 90,004,273,000)/2	= 184,069,796,000
Total Intralata Toll Call-Minutes	= 20,085,374,000 × 4.1	= 82,350,033,000
Total Local Call-Minutes	= 400,337,030,000 × 4.1	= 1,641,381,823,000
Total Call-Minutes		1,907,801,652,000

Total PSTN Lines = 15,258,909 + 20,569,866 + 1,677,195 + 88,416,430 + 23,734
= 125,946,134 lines

Average Call-Minutes/Line = 1,907,801,652,000/125,946,134 = 15,148 call-minutes/line

Resulting Time Utilization per line = 15,100/525,600 min/yr = **0.03 Erlangs**

CERTIFICATE OF SERVICE

I, Jean J. Layton, hereby certify that a copy of the foregoing Comments of PCN America were mailed, postage prepaid, this 9th day of November, 1992, to the following parties.

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

	)	GEN Docket No. 90-314
	)	ET Docket No. 92-100
In the Matter of	)	
	)	RM-7140, RM-7175, RM-7617
	)	RM-7618, RM-7760, RM-7782,
Amendment of the Commission's	)	RM-7860, RM-7977, RM-7978
Rules to Establish New Personal	)	RM-7979, RM-7980
Communications Services	)	
	)	PP-35 through PP-40, PP-79
	)	through PP-85

LICENSING PROPOSAL OF PCN AMERICA, INC.

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October 20, 1992

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SUMMARY

Millicom proposes a three-tiered licensing plan for Personal Communications Services (PCS). Tier One would consist of two competing National Network Operators (NNO) which would select PCS technology and provide for nationwide interconnection, billing, roaming, and database functions. NNOs would not construct cell site facilities or provide direct service to the public. Tier Two would consist of ninety-eight regional licensees (one operating on each of two frequency blocks) serving forty-nine Major Trading Areas (MTA). The MTA licensees would construct PCS radio, switching, and network facilities and would provide service to the public. Tier Three would consist of local and rural licensees (a minimum of twenty-five per frequency block) within each MTA. To provide spectrum and geographic operating areas for the Tier Three licensees each Tier Two (MTA) licensee would be required to relinquish at least 30% of the land area and 25% of the population within its MTA.

This three tiered licensing plan would ensure rapid deployment of PCS services with nationwide compatibility, roaming capability, and database features. It would avoid the delays and transaction costs experienced by the cellular industry while providing an opportunity to participate in the PCS industry for over 2500 licensed entities large and small.

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Communications Services	)	
	)	PP-35 through PP-40, PP-79
	)	through PP-85

To: The Commission

LICENSING PROPOSAL OF PCN AMERICA, INC.

PCN America, Inc., a subsidiary of Millicom Incorporated, referred to herein jointly as "Millicom," hereby submits preliminary comments on the licensing of Personal Communications Services ("PCS") pursuant to the procedures set forth in Amendment of the Commission's Rules to Establish New Personal Communications Services, FCC Gen. Docket No. 90-314, ET Docket No. 92-100, FCC 92-333, released August 14, 1992 ("NPRM"). This filing will propose a licensing structure for PCS. It is submitted prior to the prescribed comment period to encourage interested parties to discuss this licensing proposal in their comments.[1]

[1] Millicom will submit comments addressing the remaining issues raised by the NPRM on the Commission's prescribed comment date.